Second Use of Electric Vehicle Batteries in Stationary Applications

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Outline

- **Background**
- **Study tasks**
- **Status**
- **Future work**
- **Acknowledgements**

Background

- **Objectives of this Phase I Study**
  - Evaluate feasibility of using “spent” EV/HEV batteries in stationary applications
  - Identify criteria and possible partners for a demonstration project
- **Objectives of future phases**
  - Additional laboratory testing
  - Field trial/demonstration
- **Ultimate goals**
  - Reduce net cost of batteries to EV owner
  - Make advanced batteries available for stationary applications

Study tasks

1. **Gather battery-related information**
2. **Identify opportunities for stationary battery energy storage**
3. **Define the issues in reusing spent EV batteries**
4. **Perform economic analysis for re-use process**
5. **Identify criteria and partners for possible demonstration**
6. **Prepare Final Report**

Status: Battery-related information

- **Is there any experience in reusing batteries?**
  - Peer reviewed technical journals
  - Previous studies
  - Personal contacts
- **Findings**
  - There is an active secondary market for used batteries
    - Battery chemistries
      - Lead acid most popular
      - Ni-Cd, Ni-Fe, Ni-MH, Lithium ion (?)
    - Applications
      - Renewable energy systems
      - Ham radio systems
      - Laptop computers (?)

Status: Battery-related information

- **ANL/USABC study (1996-1997)**
  - Used Ni-MH batteries from EV test program were evaluated for stationary applications
  - Batteries were tested per USABC test protocol
    - 500 DST cycles to 80% DOD, simulating EV use
  - Evaluated for stationary applications
    - Utility load management
      - Load following
      - Frequency regulation and spinning reserve (UES Cycle)
    - Uninterruptible power systems (UPS)
- **Findings**
  - Performance competitive with new lead acid batteries

Status: Battery-related information

- **Battery testing & condition of batteries at EOL**
  - Review EV/HEV battery test manuals
    - USABC, PNGV, MATADOR Task 2
  - Visit battery makers and battery test laboratories
    - ANL, SAFT, Ovonic/ECD
- **Findings**
  - Testing is expensive but necessary
  - Testing after EOL probably at module level
    - Predict future life
    - Sort/match for future reassembly
  - Cycling could give data for predicting future life
    - C/3 capacity and internal impedance
    - 3 to 5 cycles may be enough

Status: Battery-related information

- **Auto industry perspectives**
  - Ford, GM, DaimlerChrysler
- **Findings**
  - Batteries will be owned by vehicle buyer
  - In case of problem dealers will…
    - replace EV modules if before expected EOL
    - replace entire HEV battery
  - At EOL dealers will…
    - remove & disassemble EV batteries
    - remove HEV batteries as unit

Status: Identify opportunities

- **Looked at three size categories**
  - Utility/industrial
  - Commercial
  - Residential
- **Determined energy storage requirements**
  - Load characteristics
    - Energy
    - Power
    - Duty cycle

Status: Identify opportunities

APPLICATION	DISCHARGE TIME	PEAK POWER	AVERAGE POWER	ENERGY DELIVERY	FREQUENCY OF USE
Transmission Stabilization	10 sec (up to 5 pulses)	500 MW	N/A	< 500 MWs/ pulse (140 kWh)	1/month
Area Regulation & Spinning Reserve	12 min? 15 min full power, 15 min ramp down	20 MW 20 MW	±10 MW 20 MW	±2MWh 7.5 MWh	1/15 min 1/month
Load Leveling / Energy Arbitrage / Transmission Deferral	5-10 hrs	N/A	10 MW/ 15 MVA	100 MWh	100–200 days/yr (weekdays w/high demand)
Renewables Firming	1 hr or 10 hr	5 MW	1 MW	1–10 MWh	10–20 days/month
Power Reliability & Peak Shaving	3-4 hrs	2 MW	1 MW	3–4 MWh	6/yr 1/day, max.
Light Commercial Load Following	3 hr at average power, overnight at low power	200 kW	25 kW ?	75–100 kWh	1 high DOD cycle/day, many low DOD subcycles
Residential Load Following	3 hr at average power, overnight at low power	10 kW	1 kW	3–4 kWh	1 high DOD cycle/day, many low DOD subcycle
Distributed-Node Telecomm Standby Power	5-10 hrs	5 kW	< 5 kW	25–50 kWh	2/yr

Status: Identify opportunities

- **Utility/Industrial applications**
  - Utility load leveling/ energy arbitrage (100,000 kWh)
    - Extremely large system
  - Renewables firming (1,000–10,000 kWh)
    - Frequent, low rate (C/5) discharges
  - Area regulation & Spinning reserve (5,000–7,500 kWh)
    - Infrequent, high rate (C/2 – C) discharges
  - Power reliability/Peak shaving (3,000–4,000 kWh)
    - Power reliability: infrequent, moderate rate (~C/2) discharges
    - Peak shaving: daily, moderate to high rate (C/2 – C) discharges
  - Transmission stabilization (140 kWh)
    - 500,000 kW second pulses
    - 5 pulses/10 seconds, once/month

Status: Identify opportunities

- **Commercial applications**
  - Peak shaving (3,000–4,000 kWh)
    - Daily, moderate to high rate (C/2 – C) discharges
  - Customer-side load following (75–100 kWh)
    - 1 deep discharge and several shallow discharges per day
      - C/3 discharge rate typical
  - Distributed node telecommunications
    - Standby power
    - Infrequent, low rate (C/5) discharges

Status: Identify opportunities

- **Residential applications**
  - Renewable systems (up to 25 kWh for off-grid)
    - Daily, moderately deep (>50% DOD) discharges
  - Self-generation load following (3–4 kWh)
    - 1 deep discharge and several shallow discharges per day
      - C/3 discharge rate typical

Current activities

- **Finishing data gathering**
  - Lead-acid batteries
  - Batteries used in heavy hybrids
- **Setting-up framework for economic analysis**
  - Production systems
    - When EVs/EHVs are common
  - Demonstration
    - Near term

Remaining tasks

- **Complete economic analysis**
  - Executive-level
- **Recommendations for follow-on phases**
  - Identify need for additional laboratory testing
  - Identify possible demonstration projects
    - Criteria
    - Partners
- **Prepare Final Report**
  - Draft by December 31, 2001
  - Final by January 31, 2001

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